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(54) Method and arrangement for improving leak tolerance of an earpiece in a radio device

(57) The invention relates to an arrangement for improving leak tolerance in an earpiece (100) of a radio device. The invention can be applied preferably in mobile stations. One idea of the invention is that an acoustic volume (111) is arranged behind the earpiece by taking advantage of the RF shield casing (112, 116) of a radio frequency unit of the device. By means of the invention one can form behind the earpiece an acoustic volume which loads optimally the earpiece without therefore needing to enlarge the size of the device. In an embodiment of the invention one wall of the casing arranged behind the earpiece has been formed by means of an electronic circuit board (112), to which circuit board radio frequency components (117) of an electronic unit have been connected. Then between the casing and the external volume one can preferably form an acoustic path by means of through holes (113, 114) arranged in the circuit board.

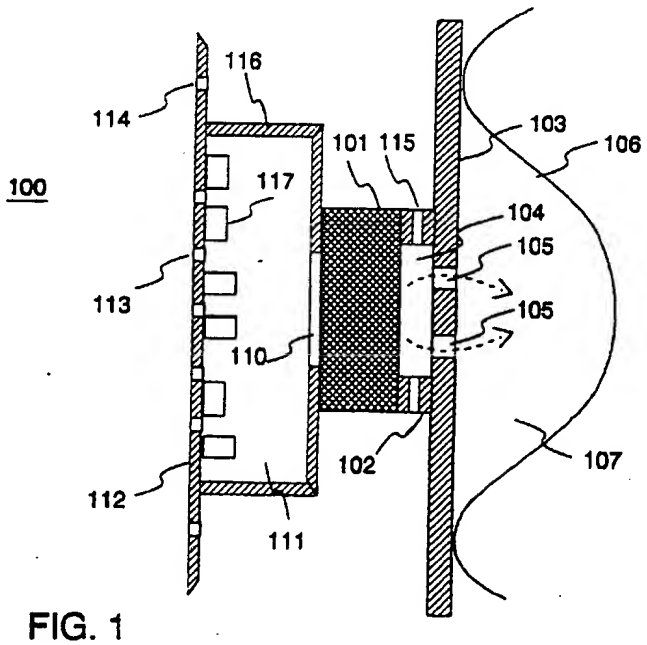

FIG. 1

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- a housing part situated between the earpiece capsule and the user's ear for confining the acoustic volume between said housing part and user's ear and
- the first acoustic path arranged between the front part of the earpiece capsule and said acoustic volume for directing sound from the front part of the earpiece capsule to said acoustic volume,

is characterized in that the arrangement comprises additionally

- a radio shielded volume confined by a casing and arranged for the RF parts of the mobile station and
- the second acoustic path for directing sound formed by the earpiece capsule from the back part of the earpiece capsule to said radio shielded volume for improving the leak tolerance of the earpiece.

[0013] Preferable embodiments of the invention have been presented in dependent claims.

[0014] By the front and back parts of the earpiece capsule one means herein the front and back parts of a membrane which forms sound waves and is situated in the earpiece capsule, and sound waves generated in these front and back parts are in opposite phases from each other.

[0015] By the earpiece one means herein the earpiece capsule and acoustic and mechanical structures connected to it.

[0016] In the following the invention is described in more detail by means of the attached drawings in which

fig. 1 shows an earpiece arrangement according to the invention for improving leak tolerance of an earpiece.

fig. 2 shows an acoustic equivalent circuit of the earpiece arrangement according to fig. 1,

fig. 3 shows another arrangement according to the invention for improving leak tolerance of an earpiece,

fig. 4 shows an acoustic equivalent circuit of the earpiece arrangement according to fig. 3,

fig. 5 shows a block diagram of a prior known mobile station to which the present invention can preferably be applied and

fig. 6 shows a front view and a side view of a mobile station according to the invention.

[0017] Fig. 1 shows an earpiece 100 according to prior art. It comprises an earpiece capsule 101 which converts an electric signal into an acoustic sound. The earpiece capsule 101 is connected to the housing 103 of the earpiece by its edges 102. The sound wave formed by the earpiece capsule is generated in the volume 104 between the earpiece 101, the edges 102 and the housing 103, from which it is transferred to the external volume of the housing through holes 105. Between the housing 103 and the ear 106 there remains a volume 107 which thus in an optimal situation is closed. If the earpiece is a part of a mobile station, the housing 103 is preferably the cover of the mobile station.

[0018] In the solution shown in Fig. 1, leak tolerance has been improved by arranging an acoustic volume 111 behind the earpiece capsule. From the earpiece capsule, acoustic connection has been arranged to said volume by means of one or more holes 110 situated in the back part of the earpiece capsule. The acoustic volume has been confined by means of a casing which consists of an RF shield 116 and a circuit board 112. The RF shield 116 has been manufactured from some electrically conductive material, such as a metal plate. The circuit board 112 has preferably holes which connect acoustically the volume 111 to the volume surrounding it. In the circuit boards, holes with plated-through edges are used to electrically connect wires to each other, these wires being situated on different foil layers of the circuit board. These approximately 0.2 mm diametral holes can be used for forming said acoustic path. Fig. 1 shows also RF components 117 of a radio frequency unit which have been connected to the circuit board 112.

[0019] The acoustic return path of the earpiece capsule can thus be arranged via the volume which surrounds the entire device, but Fig. 1 also shows a way to arrange an internal acoustic return path of the device. This acoustic return path consists of a hole 110 in the back part of the earpiece capsule, an acoustic volume 111 behind the earpiece capsule, holes 113 in the circuit board at the position of the RF shield casing, holes 114 in the circuit board outside the RF shield casing, a volume between the circuit board and the housing part and holes 115 at the front edge of the earpiece capsule. The volume arranged for said acoustic return path between the circuit board and the housing part can additionally be confined by a special second casing, but the volume can also consist of a normal casing of the device, such as a mobile station, and the components inside it.

[0020] The ability to improve leak tolerance in the solution shown in Fig. 1 is based on the fact that the acoustic volume arranged behind the earpiece and the acoustic return path arranged through it, operate as an acoustic load of the earpiece capsule especially at low frequencies, in which case the changes in external load have a smaller relative effect on the acoustic total load of the earpiece capsule.

[0021] Fig. 2 shows an acoustic equivalent circuit of an earpiece according to Fig. 1. In it, the earpiece capsule forms a pressure wave and operates as an acoustic source 201 and comprises an internal impedance 204. The pressure wave propagates to the outside of the earpiece arrangement through holes in the casing, such

scribed and thereafter, the mechanical structure of a mobile station according to the invention is described by means of Fig. 6.

[0030] Fig. 5 shows a block diagram of a mobile station according to an embodiment as an example of the invention. The mobile station comprises the parts which are typical of the device, such as a microphone 531, a keyboard 537, a display 536, an earpiece 501, a transmission/reception coupling 538, an antenna 539 and a control unit 535. Additionally, the figure shows transmission and reception blocks 534, 541 which are typical of the mobile station.

[0031] The transmission block 534 comprises operations needed for speech coding, channel coding, ciphering and modulation, and RF operations. The reception block 541 comprises corresponding RF operations and operations needed for demodulation, deciphering, channel decoding and speech decoding. A signal which comes from the microphone 531, which has been amplified at an amplification stage 532 and converted into a digital form in an A/D converter is transferred to the transmission block 534, typically to a speech coding element included in the transmission block. The transmission signal which has been shaped, modulated and amplified by the transmission block is directed via the transmission/reception coupling 538 to the antenna 539. The signal to be received is brought from the antenna via the transmission/reception coupling 538 to the reception block 541 which demodulates the received signal and performs the deciphering and channel decoding. The speech signal received as a final result is transferred via a D/A converter 542 to an amplifier 543 and further to an earpiece 501. The control unit 535 controls the operation of the mobile station, reads control commands given by the user from the keyboard 537 and delivers messages to the user via the display 536.

[0032] The parts of the mobile station to be RF shielded are included in blocks 538, 534 and 541. The RF parts of the transmission block 534 and the reception block 541, such as circuits forming the RF frequency signals, can also be partially common to the transmission and reception chains.

[0033] When an earpiece arrangement according to the invention is used, the frequency response of the earpiece may differ from the frequency response of the arrangement according to prior art. The frequency response can be compensated analogically by using a filter which is included in the amplifier 543. Another alternative is to perform the compensation in the context of digital signal processing in the digital signal processor (DSP) of block 541. When the frequency response is corrected on the digital signal processor, component changes are not necessarily needed, but the correction can be performed by making the necessary additions to the program which controls the digital signal processor.

[0034] Fig. 6 shows a mechanical structure of a mobile station 600 according to the invention viewed from the front and the side. The side view has been enlarged by 2:1 compared to the front view and it shows a partial cross section A-A at the position of an earpiece according to the invention. The front view shows a microphone 631, a keyboard 637, a display 636 and an antenna 639 which are included in a conventional mobile station. On the top part of the mobile station one can see holes 605 which form the first acoustic path leading from the front part of the earpiece capsule to the outside of the device and holes 620 which are a part of the second acoustic path. In the cross-sectional view, one can additionally see an RF shielded volume 611 which has been arranged behind the earpiece capsule. The volumes 611 and 631 need not necessarily be separated but they can also form a combined volume. The housing of the earpiece between the earpiece and the user's ear is in the mobile station preferably the cover 603 of the device to which other mechanical parts of the earpiece are connected.

[0035] As one can see in Fig. 6, both the earpiece and the antenna are situated in the top part of the mobile station. Since the RF parts are directly connected to the antenna circuit, the locating of the RF shield in the context of the earpiece is also RF technically a good solution.

[0036] Above, some embodiments of the solution according to the invention have been described. The principle according to the invention can naturally be modified within the frame of the scope defined by the claims, for example, by modification of the details of the implementation and ranges of use.

Claims

1. A method for improving leak tolerance in an earpiece (100, 300) of a radio device, at which the sound formed by an earpiece capsule (101, 301) is directed from the front part of the earpiece capsule to a first acoustic volume (107, 307) which is confined by the user's ear (106, 306) and a housing part (103, 303) between the earpiece capsule (101, 301) and the ear (106, 306), **characterized** in that the sound formed by the earpiece capsule is directed additionally from the back part of the earpiece capsule to a radio shielded volume (111, 311) of the radio device, and this volume is confined by a casing and it operates as the second acoustic volume.

2. An arrangement for improving leak tolerance of an earpiece (100, 300) in a radio device, which arrangement comprises

   - an earpiece capsule (101, 301),
   - a housing part (103, 303) between the earpiece capsule (101, 301) and the user's ear (106, 306) for confining a first acoustic volume (107, 307) between said housing part and user's ear (106, 306) and

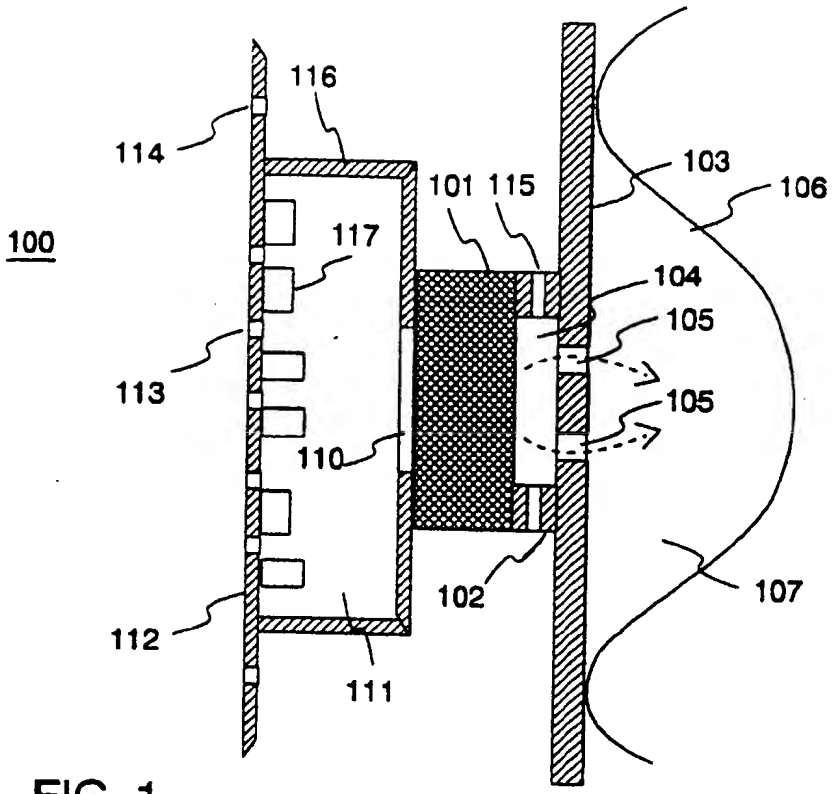
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FIG. 1

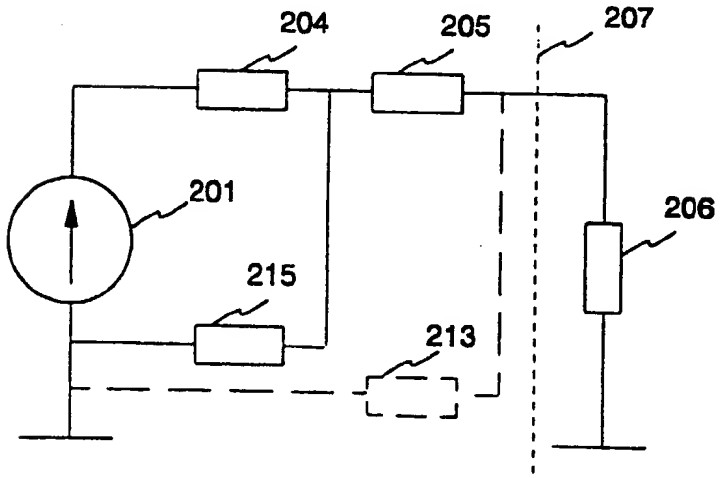
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FIG. 2

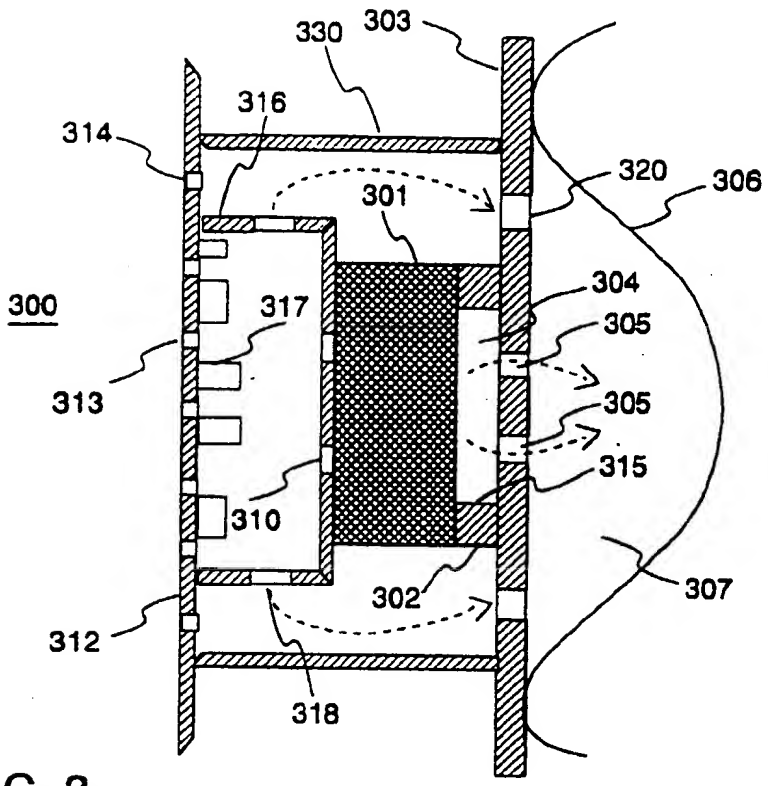
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FIG. 3

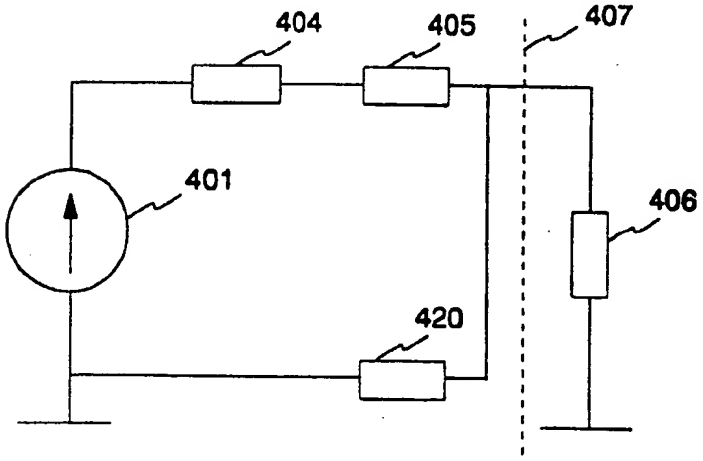
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FIG. 4

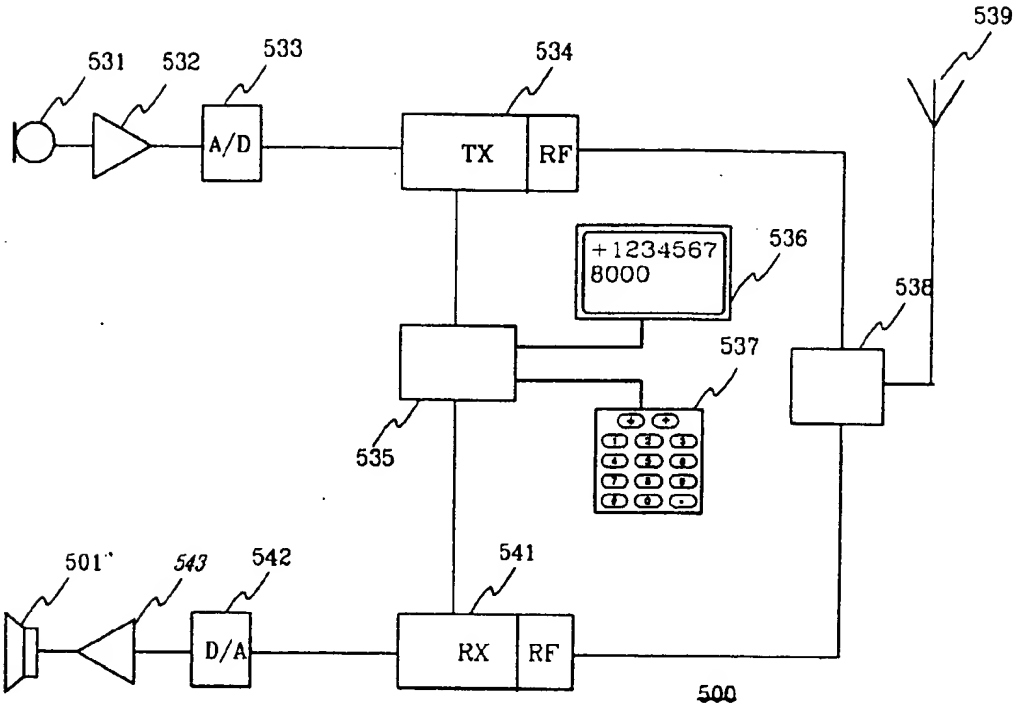
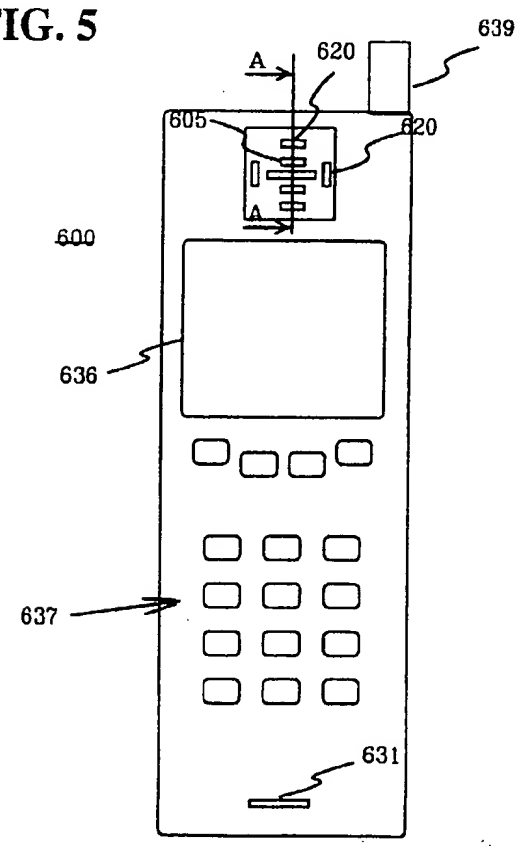


FIG. 5



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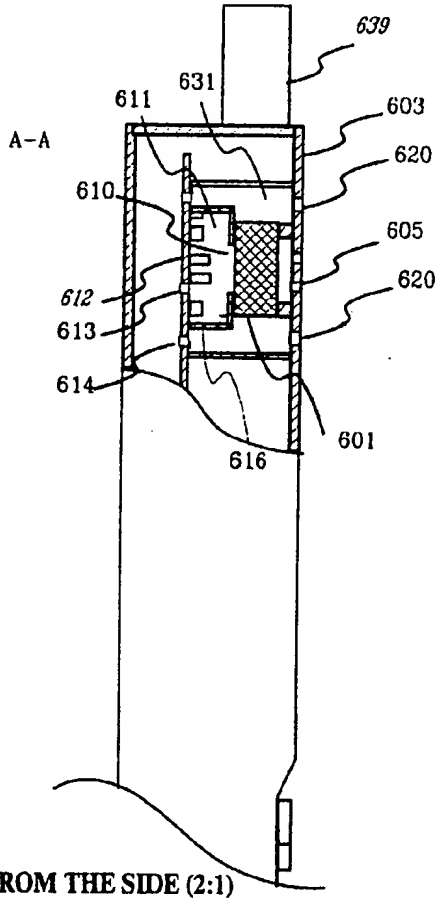

FROM THE SIDE (2:1)

FIG. 6